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METAL-FRAMED PARTITIONS WITH REDUCED THICKNESSES:

Part 2 – Built-in acoustic treatment

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Summary

Laboratory measurements were made of the sound insulations and absorption coefficients of a range of metal-framed partitions having built-in acoustic treatment. The optimun constructions for single and double leaf absorbent partitions had marginally lower sound insulations (approximately 1 dB) than those of comparable single and double metal-framed Camdens. The effective absorption coefficient curves of the new partitions were reasonably flat between 50 Hz and 10 kHz.

Savings in studio floor areas of up to 25% should be possible by using the new partitions rather than metal-framed Camdens fitted with conventional modular acoustic treatment. The partitions should have similar construction costs and weights to those of metal-framed Camdens.

An initial assessment was made of the expected structural loadbearing performances and fire resistances of these partitions. However, a further assessment by specialists will be necessary before the partitions can be recommended for use in studio construction.

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1. INTRODUCTION

The timber-framed 'Camden'[1] is a lightweight partition that has been in widespread use for studio construction throughout the BBC since it was designed for the Camden studios in the 1940s. It has a high level of sound insulation for its weight.

To reduce the construction time and costs of the Camden, the timber studs can be replaced by proprietary metal studs. Recent studies[2] have shown that the sound insulation of a metal-framed Camden is slightly higher than that of an equivalent timber-framed Camden.

To achieve the required level of sound insulation, different numbers of independent, close-spaced leaves may be constructed: single, double and triple Camdens are common. One disadvantage that is often mentioned by BBC Architects is that the partitions are quite thick (a triple Camden with conventional modular acoustic treatment fitted on both sides is approximately 0.9 m thick). To increase the usable floor area, it would be necessary to reduce the overall thicknesses of the partitions without seriously affecting the sound insulations.

One possible approach, described in a companion Report[3], is simply to reduce the widths of the studs and of the cavities between the leaves. Moderate reductions in these widths have been shown in that Report to have very little effect on the sound insulations of the partitions. However, these partitions would still have modular acoustic treatment fitted, as with the conventional Camdens.

Another possible method for reducing the overall thicknesses of the partitions would be to build the studio acoustic treatment into the partitions. The purpose of the work described in *this* Report was to determine whether it was possible to design partitions having built-in acoustic treatment that would meet the requirements of partitions for use in studio construction.

2. THE DESIGN STRATEGY

2.1 Requirements of the partitions

The overall sound insulations of partitions with built-in acoustic treatment were expected to be lower than those of comparable Camdens. This is because the absorbent leaves must be perforated. In return for the reduced overall partition thickness, some degradation in sound insulation might have been acceptable, although the shortfall had to be minimised.

One advantage of existing BBC modular acoustic treatment is that the overall quantity of absorption and the relative proportions of low and high frequency absorption can be tailored to the needs of a particular room. A sensible design target for partitions with built-in acoustic treatment was that they should have a wideband, flat absorption coefficient curve. The overall level of absorption would then be controlled by leaving some of the walls untreated.

Camden partitions are usually required to support moderate structural loads. In 'box-within-box' studios, the partitions typically support ceilings made from woodwool slabs. Any new absorbent partitions must therefore be capable of supporting, with additional bracing if necessary, heavy acoustic doors and observation windows. The partitions must also be able to support loads such as shelves or monitors mounted on brackets.

For studio applications, the partitions must have an adequate fire resistance between studio areas. This fire resistance is related to the number of layers of plasterboard, the number of cavities and the quantity of mineral wool in the partitions. Structural or semi-structural steelwork must be shielded from possible fire damage.

Studios having built-in acoustic treatment must not be significantly more expensive than studios constructed from Camdens, fitted with modular acoustic treatment. However, a slight increase in cost might have been acceptable in return for savings in the floor area.

For the partitions with built-in acoustic treatment, a multi-leaf, box-within-box type of construction, similar to that of the conventional Camden, was to be retained and separate rooms would be independently floated. This construction usually gives good isolation from structure-borne sound and provides relatively high levels of airborne sound insulation.

2.2 Selection of materials

Most of the absorption of the partitions was provided by RW2 grade Rockwool in the cavities of

the absorbent leaves. This grade of Rockwool gives effective absorption for its weight, cost and thickness. Moderate depths of this mineral wool have been shown[4] to provide reasonable wideband absorption when the material was laid directly on a reflective surface. Two thicknesses of mineral wool were used in the partitions tested; 150 mm (the maximum width of metal stud manufactured by Redland Plasterboard) and 75 mm (the width of the second widest Redland metal stud and the minimum thickness of mineral wool likely to provide adequate absorption).

For sections of the partitions having wideband absorption, the faces were covered with 24% perforated, 0.7 mm thick galvanised steel sheet. The perforated steel sheet is smooth, robust and should have virtually no effect on the absorption. Other materials, such as perforated hardboard or aluminium sheet, were rejected on grounds of strength or cost.

For relatively unabsorbent sections of the partitions, the faces were covered by unperforated 0.7 mm thick steel sheet. For these relatively unabsorbent sections, the cavity was still completely filled with RW2 Rockwool for three reasons; to damp the motion of the steel, to provide adequate sound insulation and to prevent flanking transmission of sound at the boundaries between absorbent and relatively reflective sections. The relatively reflective sections were expected to provide a certain amount of low frequency absorption because of damped resonances in the steel facing and in the plasterboard/fibreboard backing to the absorbent leaves.

The perforated and unperforated steel sheets contribute to the structural strength of the partitions. Additional strengthening of the partitions may be necessary, particularly to provide adequate fire resistance. This matter is discussed later in more detail.

For single leaf partition tests, either Redland[5] CS70/R or CS146/R metal studs were used, the choice depending upon the depth of Rockwool required. For absorbent leaves that are constructed next to single leaves (these must be constructed from one side and they are named Shaftwall leaves), either CHS102/W studs (containing 75 mm Rockwool) or CS70/R studs fixed to CHS102/W studs (containing 150 mm Rockwool) were used.

In multi-leaf partitions, only some of the leaves need to contain absorption. The remainder can be constructed as conventional Camdens. In a typical studio construction, the single leaf partitions may be either absorbent partitions or conventional metal-framed single Camdens. For a double leaf partition, the Shaftwall leaf would typically face into the studio and would be absorbent. The other leaf would usually face into a corridor and therefore could be a conventional metal-framed single Camden. If both leaves of a double leaf partition were absorbent, the sound insulation would probably be inadequate. In a triple leaf partition, both outer leaves would usually face into studio areas and would be absorbent. The inner leaf would be unabsorbent and could be a single Camden.

Studies have shown[3] that the measured sound insulations of metal-framed Camdens were not reduced, either by using the narrowest Redland studs available rather than those of the conventional metal-framed Camden, or by using 30 mm rather than 50 mm cavities between the leaves. Therefore, the unabsorbent leaves of the double leaf partitions tested would contain the narrow CS50/R studs. In typical studio constructions, these unabsorbent leaves would be non-loadbearing. Cavity widths of 30 mm were used.

2.3 Two possible types of partition

Two types of partition were initially considered. Fig. 1 shows examples of single leaf versions of the two types of partition (the key also applies to the remainder of the figures in this Report). The first example shows 'bolt-on' absorption; the absorption is secured to a narrow version of the metal-framed Camden. The second example shows true 'built-in' absorption. The relative merits of the two systems are:

2.3.1 'Bolt-on' absorption

The partition with bolt-on absorption is structurally stronger than the partition with built-in absorption. It also has a greater fire resistance. The partition with bolt-on absorption should have a considerably higher sound insulation than that of the partition with built-in absorption (the sound insulation should also be higher than that of the traditional Camden fitted with modular acoustic treatment).

2.3.2 'Built-in' absorption

Partitions with built-in absorption are considerably narrower than comparable partitions with bolt-on absorption (which in turn are narrower than the narrow partitions[3] with conventional modular acoustic treatment). With built-in absorption, the costs of construction in labour and materials, the overall weights and the complexities of the designs are lower than those for bolt-on absorption.

2.4 The partitions to be tested

Provided that partitions with bolt-on absorption have satisfactory absorption characteristics, they should

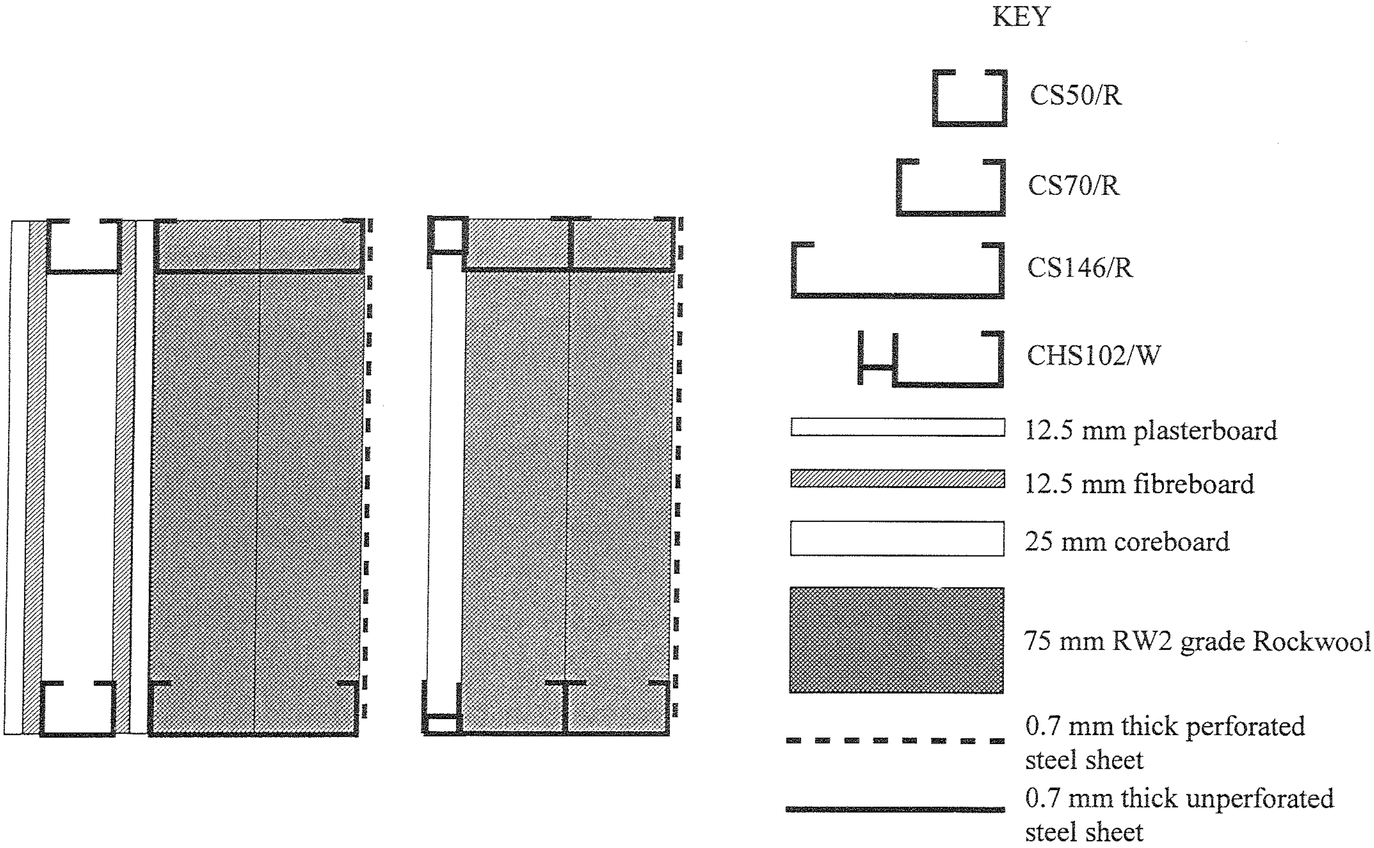


Fig. 1 - Cross-section through two types of absorbent partition.

be suitable for the construction of studios. The partitions would be structurally strong enough, they would have adequate fire resistance and more than adequate sound insulation. However, using partitions with bolt-on absorption would only result in moderate savings in floor area.

Taking these points into consideration, it was not considered necessary to perform any sound insulation or absorption tests on partitions with bolt-on absorption. However, this type of partition could be used if built-in absorption later proved to be unusable on grounds of inadequate structural strength or insufficient fire resistance (these two subjects are, to a certain extent, outside the scope of this Report).

Because the potential savings in partition thickness and cost are greater for partitions with built-in treatment, measurements were only made on a range of partitions with built-in treatment. Tests on single and double leaf partitions are described.

Sound insulation measurements were not made on triple leaf partitions, because three leaves are difficult to mount independently in the test aperture of the Transmission Suite. However, the relative performances of triple leaf partitions can, to some extent, be predicted from the measurements on the single and double leaf partitions.

3. ABSORPTION COEFFICIENT MEASUREMENTS

ISO-Standard absorption coefficient measurements were made on a number of single leaf absorbent partitions, suspended horizontally above the floor of the receive room in the Transmission Suite. The partitions were built in to a frame of size 3.6 m wide by 3.0 m high, made from 25 mm thick chipboard. Fig. 2 shows a cross-section through the frame, containing one of the partitions tested. The frame was used for three reasons; to enclose the edges of the partitions with a reflective boundary, to enable the partition to be raised for screwing boards to the undersides of the studs and to support the partitions at a known distance above the floor. The width of the cavity between the partition and the floor was 50 mm

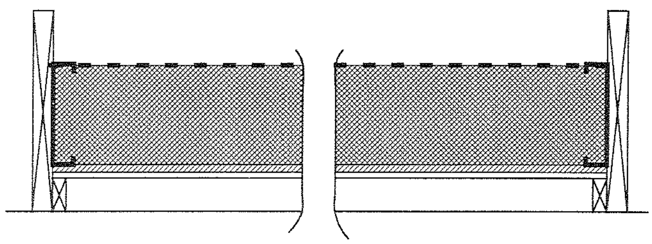


Fig. 2 - Cross-section through the frame containing an absorbent partition.

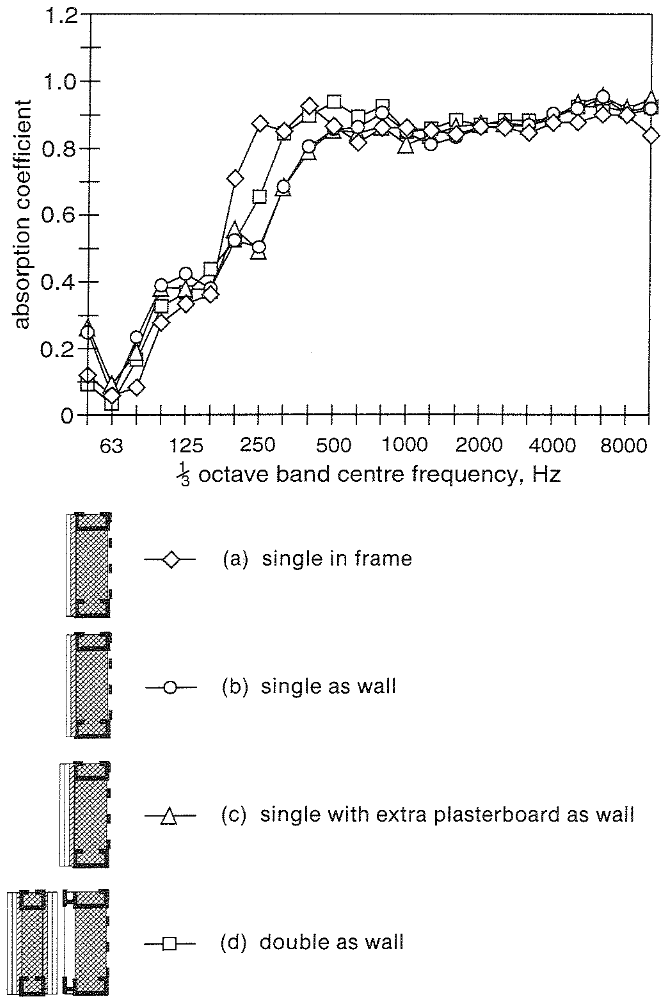


Fig. 3 - Perforated partitions using 70 mm depth RW2 Rockwool.

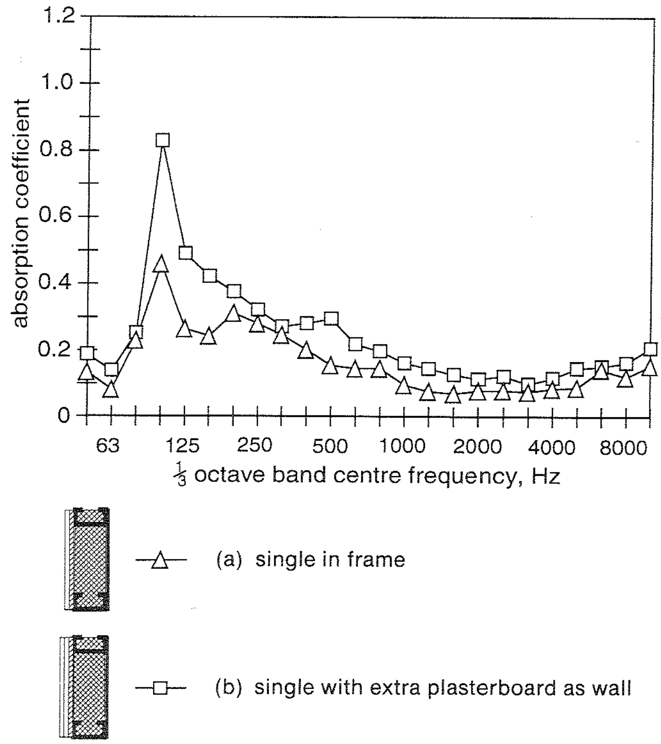


Fig. 4 - Unperforated partitions using 70 mm depth RW2 Rockwool.

(the cavity width of 30 mm used in later sound insulation measurements might not have allowed the partition to deflect under its own weight without touching the floor at its centre).

Figs. 3 - 9 show ISO-Standard measurements of the absorption coefficients of the partitions built into the frame. These figures also show the absorption coefficients of a variety of similar partitions, mounted in the aperture between the source and receive rooms for the sound insulation measurements. Because the partitions were built at the junction of the floor and a wall, the absorption coefficient measurements with the partitions built into the aperture did not meet the requirements of the ISO-Standard measurement method. However, these measurements are useful as an indication of the relative absorption coefficients of single and double leaf absorbent partitions. For these tests, the absorbent sides of the partitions were facing into the receive room.

Fig. 3 shows the measured absorption coefficients of perforated partitions containing a 70 mm depth of Rockwool. The absorption curves are typical of that usually obtained for a 70 mm depth of a porous absorber[4]. There is some variation in the roll-off at lower frequencies. Increasing the mass of the absorbent leaf by adding extra plasterboard had virtually no effect on the measured absorption.

Fig. 4 shows the absorption coefficient of an unperforated partition containing a 70 mm depth of Rockwool. The curve is typical of that observed for a damped membrane absorber. The peak of absorption at 100 Hz is probably linked with a resonance in the metal front panel, which is damped by the Rockwool. When built as a wall, the partition had a higher absorption coefficient, possibly because the level of damping is affected by what is behind the partition.

Fig. 5 shows the absorption coefficients of perforated partitions containing 146 mm depth of Rockwool. Once again, there is some variability in the roll-off at lower frequencies. The absorption at lower frequencies of the partition in the frame does not extend as low as would be expected for a porous absorber of this thickness.

Fig. 6 shows the measured absorption coefficients of different unperforated partitions containing 146 mm depth of RW2 Rockwool. The curves have similar shapes, although the absorption was lower in value when the partition was built into the frame. A comparison of the result with those for the

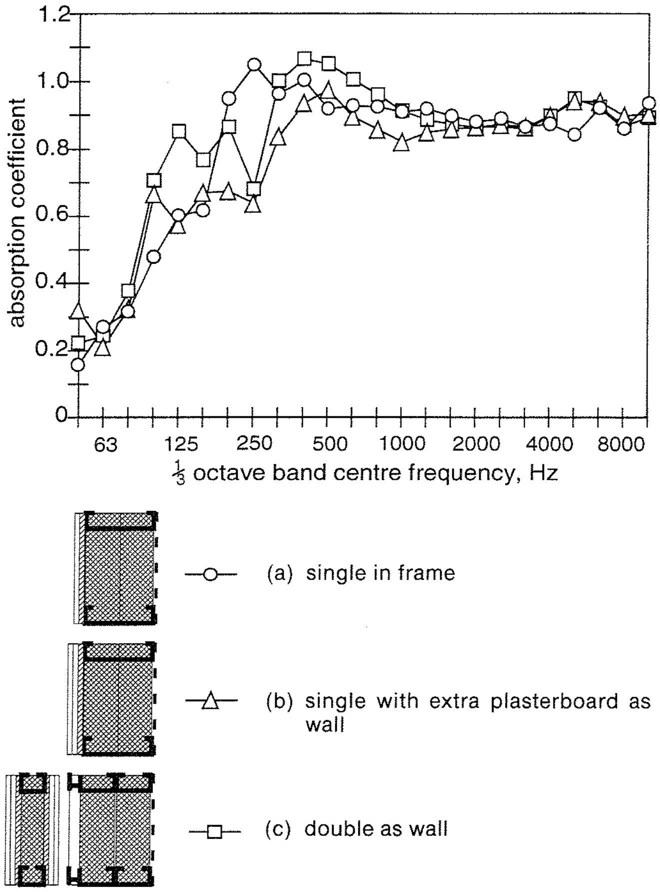


Fig. 5 - Perforated partitions using 146 mm depth RW2 Rockwool.

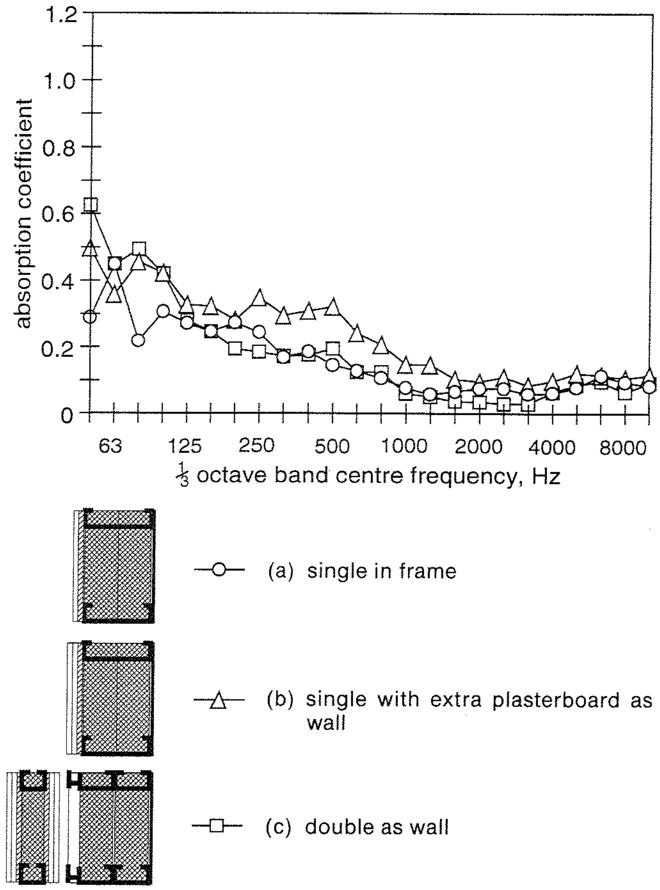


Fig. 6 - Unperforated partitions using 146 mm depth RW2 Rockwool.

unperforated absorber containing 70 mm Rockwool (Fig. 4), shows that the centre frequency of absorption seems to be related to the depth of Rockwool.

Fig. 7 *(overleaf)* shows the absorption of the partition containing 146 mm depth of Rockwool, built into the frame, with and without the perforated metal front fitted. The two curves are very similar to each other, which shows that the perforated front has virtually no effect on the absorbent properties of the partition. Fitting a 24% perforated hardboard front would have reduced the absorption of the partition at high frequencies. The difference probably arises because of the different depths of the holes in the steel and the hardboard.

For the unperforated absorbent partition containing 146 mm depth of Rockwool, the effect was measured of replacing the metal front panel with one of 3.2 mm thick hardboard. The results are shown in Fig. 8 *(overleaf)*. The differences between the two curves are not large, but fitting the hardboard has raised in frequency the range over which the partition absorbs. This is because the steel has almost twice the mass of the hardboard. The steel fronted partition is a better low frequency absorber than that with the hardboard front.

In a studio, a proportion of the walls will have to be perforated to control the reverberation times at mid and high frequencies. The remainder of the walls will be unperforated and this will provide some low frequency absorption. Typically, between 30% and 40% of the wall area will have to be perforated. To study this situation, the absorption coefficients were measured of partitions having 33% perforated and 67% unperforated frontal areas, containing either 70 mm or 146 mm depth of Rockwool. The results are shown in Fig. 9. Also shown are the overall absorption coefficients of the partitions, predicted from the absorption coefficients of the partitions with 100% perforated and 100% unperforated fronts respectively. For this prediction, the mean absorption coefficient was calculated by summing the individual absorption areas, assuming that the perforated and unperforated absorber regions do not interact.

The measured and predicted absorption coefficients show reasonable agreement with each other, although the measurements are higher than the predictions above 200 Hz. This difference occurs because the perforated and unperforated absorber areas interact to a certain extent. In particular, the Rockwool behind the unperforated sheets that is close to the junctions with the perforated sheets will provide

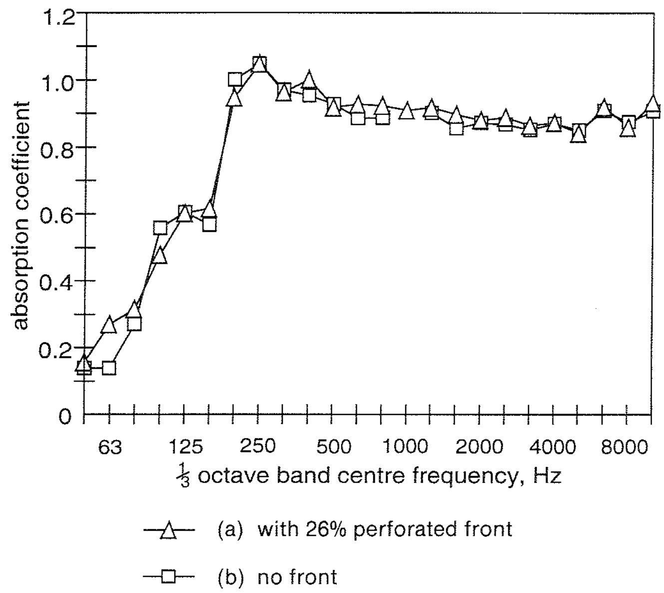


Fig. 7 - Single leaf partitions using 146 mm depth RW2 Rockwool in frame.

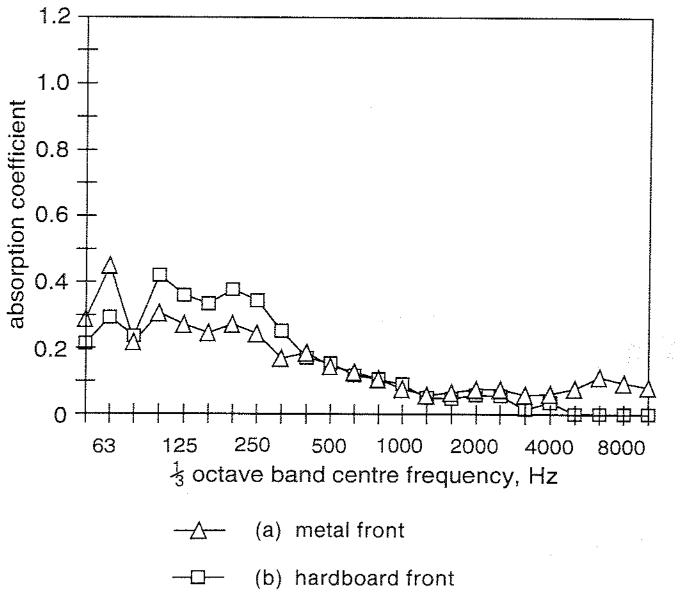


Fig. 8 - Unperforated single leaf partitions using 146 mm depth RW2 Rockwool in frame.

additional high frequency absorption. This additional absorption could have been reduced by fitting steel studs at the boundaries between the perforated and unperforated sheets where studs did not already exist. For future studio designs, it would be a reasonable approximation to sum the absorption areas of the perforated and unperforated partitioning.

The measured absorption coefficient curve for the partition containing 70 mm depth of Rockwool shows virtually no absorption below 100 Hz.

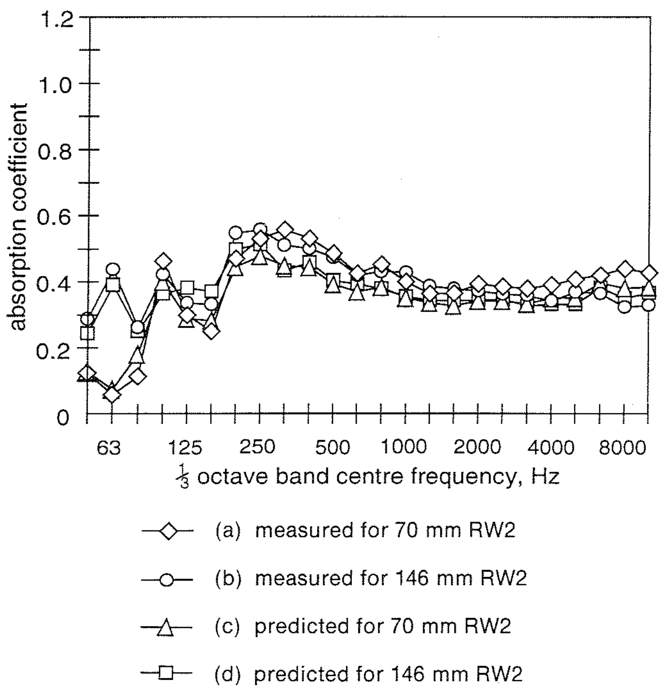


Fig. 9 - Partitions with 33% perforated and 67% unperforated fronts in frame.

Additional very low frequency modular absorbers (type A10) would probably have to be installed in a studio constructed from this type of partition to prevent an excessive rise in the reverberation time at low frequencies. There is a pronounced dip in the absorption coefficient curve at 125 Hz and 160 Hz. To a certain extent, this dip could be filled in by installing additional A2 absorbers in the room. However, the use of many additional modular absorbers in a studio is undesirable because it limits the benefits of building the absorption into the walls.

For 146 mm depth of Rockwool, the absorption below 100 Hz is higher, the dip at 125 - 160 Hz is less pronounced and overall, the absorption coefficient curve is smoother and more constant in value than that for the partition containing 70 mm depth of Rockwool. Additional modular absorbers would probably not be required in a studio with partitions containing 146 mm depth of Rockwool.

For completeness, Fig. 10 shows the predicted reverberation times in a typical studio built from absorbent partitions containing either 70 mm or 146 mm depth of Rockwool. The size of the studio is 5 m × 4 m × 3 m high and the partitions have 33% perforated fronts, the remainder being unperforated. The floor is covered with Pioneer carpet tiles and the ceiling is treated with suspended Treetex Glacier ceiling tiles. Above 250 Hz, the two reverberation time curves show very close agreement to each other. Below 250 Hz, the reverberation time characteristics are somewhat irregular. With 70 mm depth of Rockwool, the rise in reverberation time at lower frequencies is excessive and additional low frequency absorption would be required. For 146 mm depth of

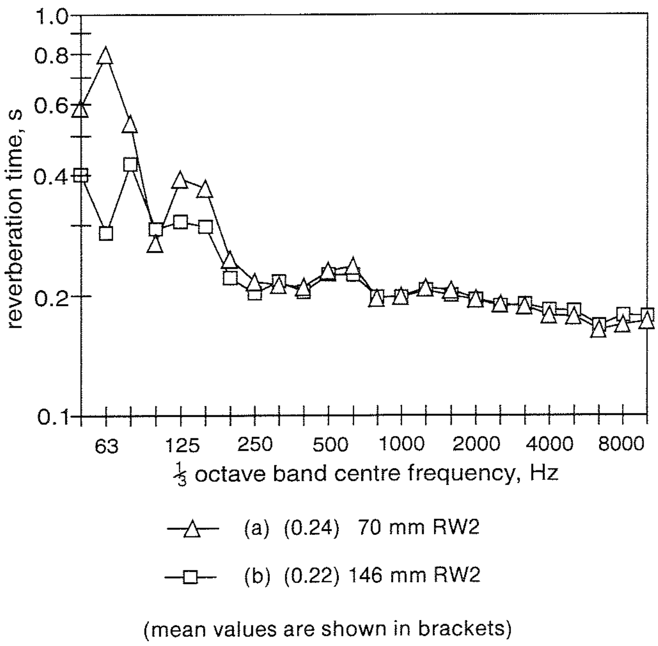


Fig. 10 - Predicted reverberation times in rooms having 33% perforated and 67% unperforated partitions with Pioneer carpet tiles and Treetex Glacier ceiling tiles.

Rockwool, the rise in reverberation time at lower frequencies is quite well controlled and the predicted reverberation time curve is acceptably smooth. If absorption were the only criterion on which the partitions were selected, the partition containing a 146 mm depth of Rockwool would be the preferred choice.

4. SOUND INSULATION MEASUREMENTS

4.1 Single leaf partitions

The sound reduction indices were measured for a variety of single leaf partitions built into the aperture between the source and receive rooms. The results are shown in Figs. 11 and 12 *(overleaf)*. Either CS70/R or CS146/R Redland metal studs were used, completely filled with either one or two layers respectively of compressed 75 mm thick RW2 grade Rockwool batts. On one side of the studs, a single layer of fibreboard was fitted, followed by either one or two layers of plasterboard. The joints at the board edges were staggered as in conventional metal-framed Camden construction and the joints were filled with Redland acoustic sealant. Either unperforated or 24% perforated steel sheets (0.7 mm thick) were screwed to the other side of the studs.

Referring to Figs. 11 and 12, adding an extra layer of plasterboard (Figs. 11(c) and 12(c)) to the partitions with 70 mm studs (Figs. 11(b) and 12(b)) increased the sound insulations at all frequencies by an average value of approximately 4 dB. Adding the extra layer of plasterboard (Figs. 11(e) and 12(e)) to the partitions with 146 mm studs (Figs. 11(d) and 12(d)) increased the sound insulations at most frequencies by an average value of approximately 2 dB. The increase in mass was responsible for the increase in sound insulation. Increasing the depth of Rockwool from 70 mm to 146 mm (by increasing the stud width) increased the sound insulations at most frequencies.

With perforated fronts, the partition using 70 mm studs and two layers of plasterboard (Fig. 11(c)) had a higher sound insulation up to 200 Hz than that of the partition using 146 mm studs and a single layer of plasterboard (Fig. 11(d)). Between 250 Hz and 6.3 kHz, the converse was true.

As a general rule, the partitions with unperforated steel fronts had higher sound insulations than those with perforated steel fronts, between 100 Hz and 500 Hz. At other frequencies, the differences were generally less significant.

In selecting a suitable partition construction, it must be remembered that a certain proportion of the face of the partition will be covered with perforated steel and the remainder with unperforated steel. The relative proportions of each covering will depend on the levels of low and mid/high frequency absorption required. The proportion of each facing present will also affect the overall sound insulation. For ease of studio construction, it would be worthwhile to select the same stud width and to have the same number of layers of plasterboard, whatever the facing.

For a typical studio, between 30% and 40% of the wall area would have to be covered with perforated steel and the remainder would be unperforated. To simulate this situation, a number of the unperforated steel panels on the face of the unperforated partition with 70 mm Rockwool and additional plasterboard (Fig. 12(c)) were replaced by perforated steel panels in a chequerboard pattern. This resulted in a 37.5% perforated, 62.5% unperforated (by area) partition.

The measured sound insulation of this partition is shown in Fig. 13. Also shown is a prediction of the sound insulation of the partition. The prediction was derived by assuming that the perforated and unperforated sections of the partition were essentially two independent partitions with areas given by the areas of the front panels. The sound insulation prediction was calculated from the sound reduction index of the partition with a 100% perforated front (Fig. 11(c)) and that of the partition with a 100% unperforated front (Fig. 12(c)) by summing the sound powers flowing through the perforated and unperforated sections.

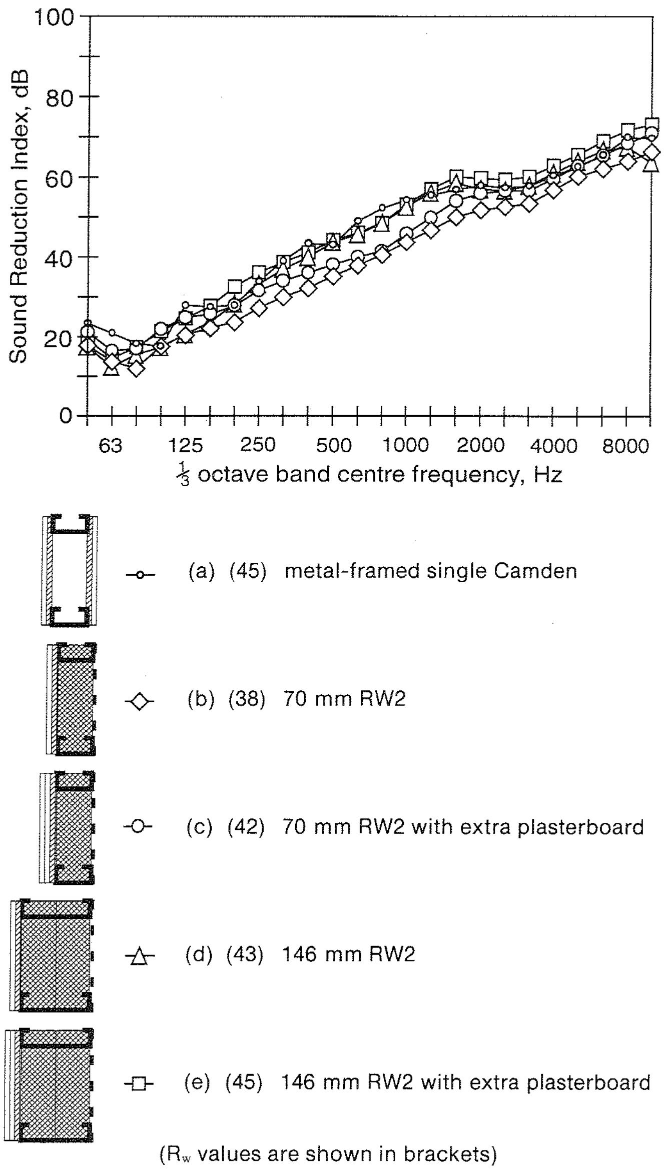


Fig. 11 - Single leaf partitions with perforated steel fronts.

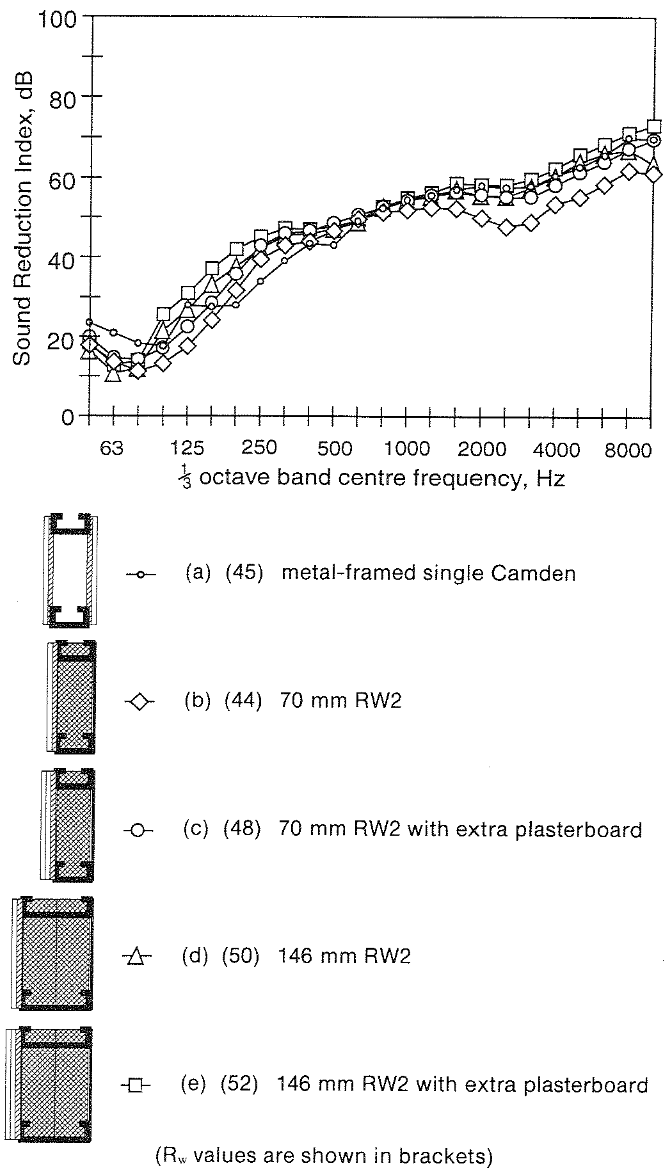
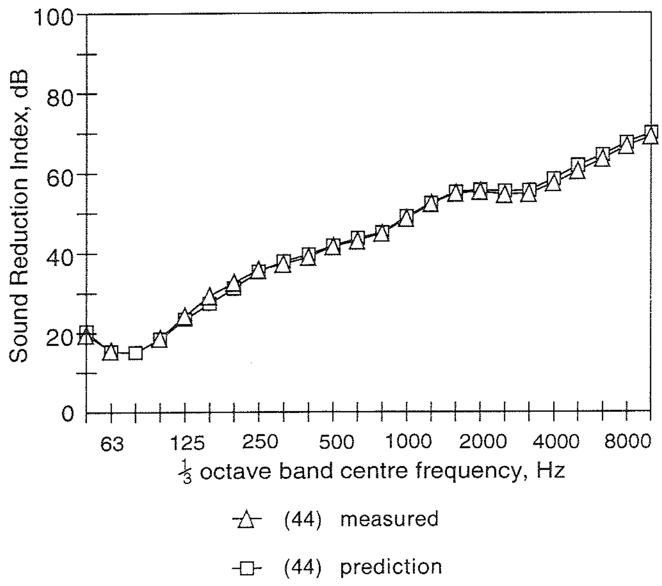


Fig. 12 - Single leaf partitions with unperforated steel fronts.

Considering that the perforated and unperforated sections of the partition will not be fully independent, the prediction shows quite close agreement with the measurement. It should therefore be possible to make reasonably accurate predictions of the sound insulations of partitions with different proportions of perforated and unperforated fronts. Fig. 14 shows similar predictions for the sound insulations of the other single leaf partitions, having 37.5% perforated fronts (except the single Camden, which is shown for reference).

The partition with 70 mm studs and additional plasterboard (Fig. 14(c)), is probably the best of the four single leaf absorbent partitions. It has the highest sound insulation from 50 Hz to 80 Hz. Above 250 Hz, the predicted sound insulation of this partition is lower than that of the metal-framed single Camden, but it is higher than that of the timber-framed single Camden[2]. This absorbent partition is a good compromise on weight, thickness, cost, sound insulation and absorption. It should have a similar fire rating for spread through the partition as a single Camden, because both partitions contain two layers of plasterboard. However, the overall fire integrity of this absorbent partition will be lower than that of the single Camden, as discussed later.

Below 100 Hz, the predicted sound insulations for all the partitions with built-in acoustic treatment are lower than that of the metal-framed single Camden. However, this difference may not be reliable because some variability has been noted in measurements at these very low frequencies. This variability is probably linked with the ways in which various room modes in the source and receive rooms of the Transmission Suite interact with different types of partition. Field sound insulation measurements will be



(R_w values are shown in brackets)

Fig. 13 - Single leaf partition with 70 mm RW2, extra plasterboard and 37.5% perforated/62.5% unperforated steel fronts.

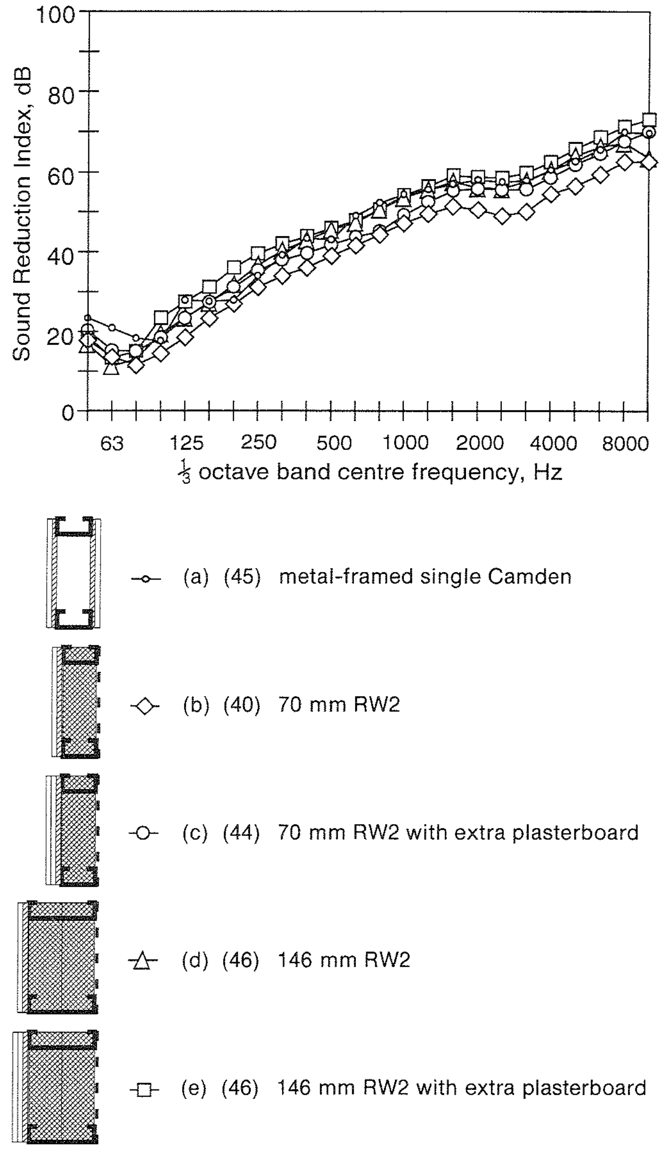
necessary to determine whether the low frequency sound insulations of the partitions with built-in acoustic treatment are comparable with those of traditional Camdens.

4.2 Double leaf partitions

In the double leaf partition tests, the first (unabsorbent) leaf to be constructed was a single metal-framed partition using narrow studs (Redland CS50/R). The narrow studs were used to minimise the thickness of the partition. There should be no load carrying difficulties because this leaf is usually not loadbearing. The width of the cavity between this leaf and the absorbent leaf was 30 mm, which is as small as can be reliably constructed without a risk of bridging between the leaves. If this cavity were enlarged and the conventional width studs (CS70/R) were used, the sound insulation would probably be unaffected[3].

For some of the double leaf partition tests, it was expected that the sound insulation of the absorbent leaf would be poor. Therefore, for these tests, an additional layer of plasterboard was fitted on both sides of the unabsorbent leaf. When an additional increase in sound insulation was required, 50 mm thick RW2 Rockwool batts were fitted in the cavity of the unabsorbent leaf.

CHS102/W Shaftwall studs were used in the absorbent leaves of the double leaf partitions. It has been shown[2] that the sound insulation of a double leaf, metal-framed partition is higher if the infill



(R_w values are shown in brackets)

Fig. 14 - Predictions for single leaf partitions with 37.5% perforated/62.5% unperforated steel fronts.

sections in the second leaf are made from 600 mm wide sections of plasterboard and fibreboard taped together, rather than 25 mm thick coreboard. Although the mass of this plasterboard/fibreboard combination is lower, the damping is greater. For the absorbent double leaf partitions described in this Report, however, a thick layer of Rockwool was in contact with the infill panels, which would damp them quite well. Therefore coreboard was used as the infill panels in the absorbent partitions. The increased mass, with damping, should give the best possible sound insulation. Also, construction with coreboard is easier than with combined plasterboard/fibreboard.

For some of the tests, the Shaftwall leaf was filled with 75 mm thick RW2 Rockwool batts. Either unperforated or 24% perforated steel sheet (0.7 mm thick) was screwed to the fronts of the studs. When a

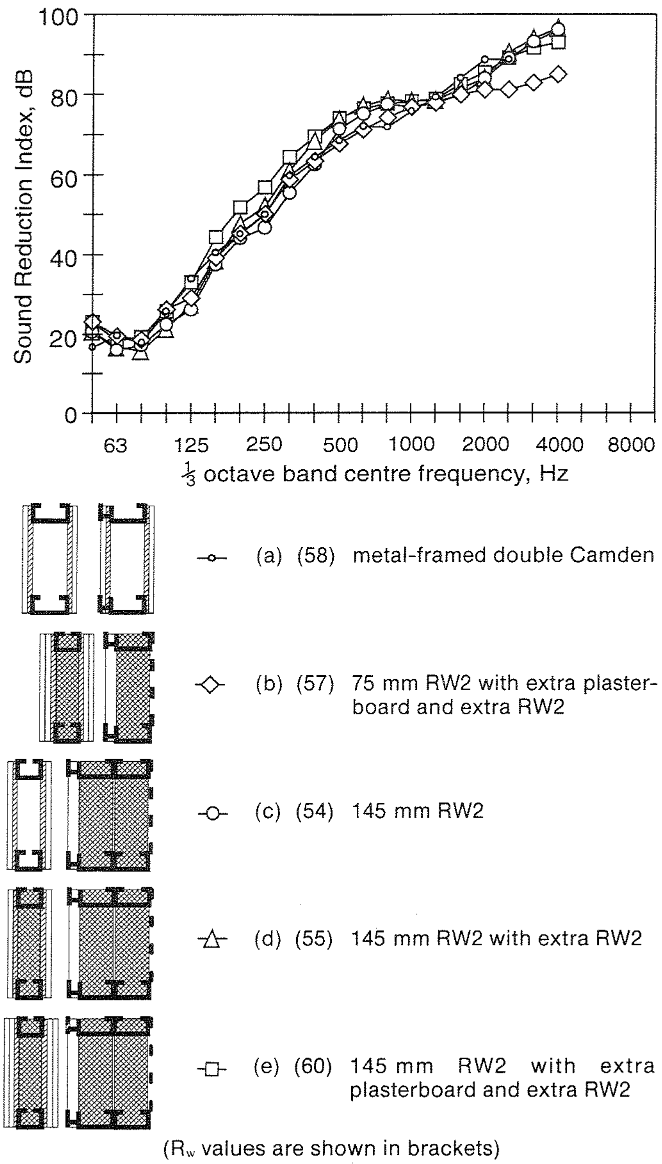


Fig. 15 - Double leaf partitions with perforated steel fronts.

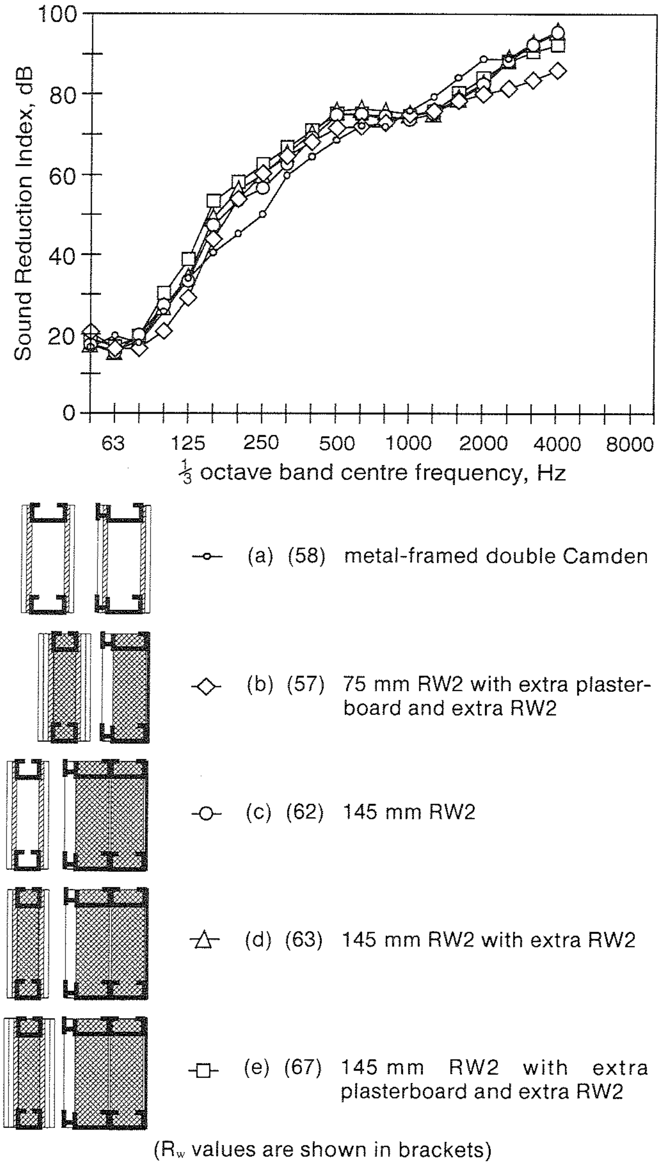


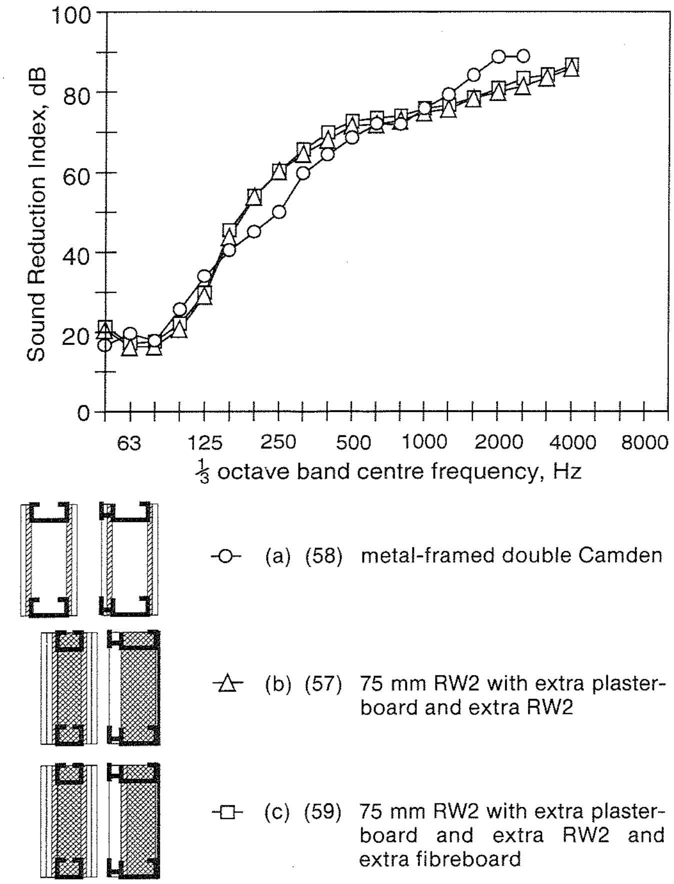
Fig. 16 - Double leaf partitions with unperforated steel fronts.

greater depth of Rockwool was required, additional CS70/R studs were screwed to the fronts of the CHS102/W Shaftwall studs and an additional layer of 75 mm thick Rockwool batts was installed before fitting the steel facing panels.

Figs. 15 and 16 show the results of sound insulation measurements on the double leaf partitions with perforated and unperforated fronts. The perforated partition with 75 mm depth of Rockwool (Fig. 15(b)) has a lower sound insulation than that of the metal-framed double Camden at 125 Hz and above 1.6 kHz (the shortfall above 1.6 kHz is not important). Otherwise, the performance of this partition closely matched that of the metal-framed double Camden.

At most frequencies, the perforated double leaf partition containing 145 mm depth of Rockwool (Fig. 15(c)) had a lower sound insulation than that of the metal-framed double Camden. When the 50 mm Rockwool batts were installed in the unabsorbent leaf (Fig. 15(d)), the sound insulation improved markedly from 125 Hz upwards. However, the sound insulation of this partition was still lower than that of the metal-framed double Camden below 200 Hz. The additional two layers of plasterboard increased the sound insulation further (Fig. 15(e)). The sound insulation between 160 Hz and 1 kHz was then significantly higher than that of the metal-framed double Camden.

Between 160 Hz and 800 Hz, the sound insulations of all the unperforated double leaf partitions are higher than that of a metal-framed double Camden. Above 800 Hz, the converse is true although this is not important. Between 63 Hz and 125 Hz, the sound insulation of the partition with 75 mm thickness of Rockwool was considerably lower than that of the metal-framed double Camden. This



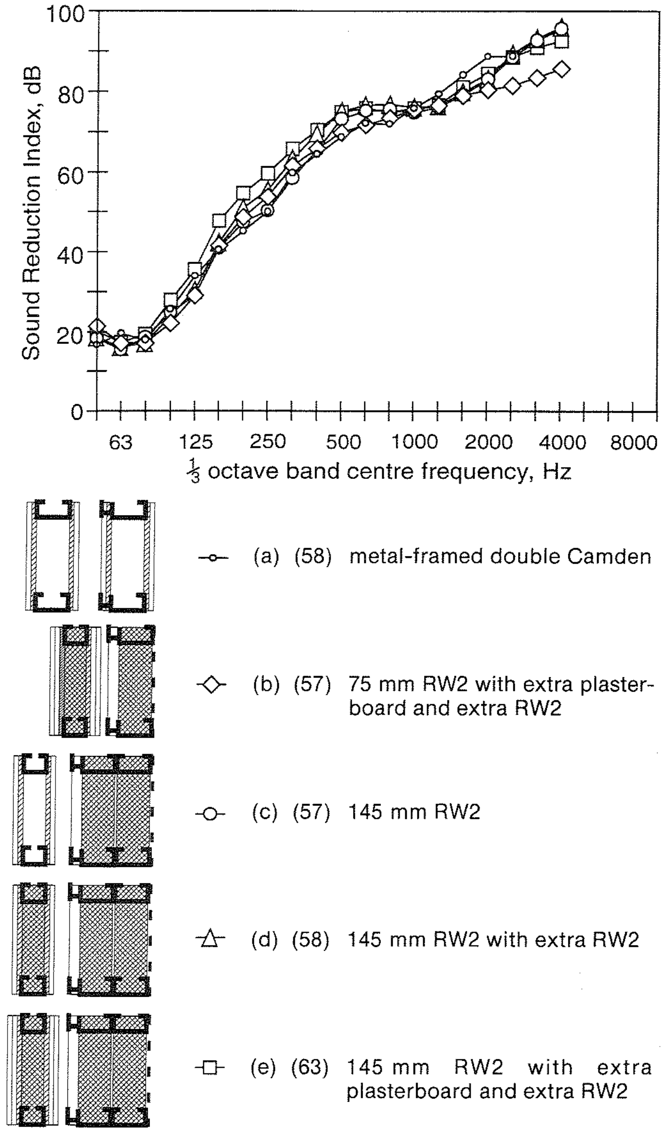
(R_w values are shown in brackets)

Fig. 17 - The effects on the sound insulation of adding an extra layer of fibreboard to an unperforated double leaf partition.

level of sound insulation would probably be unacceptable so an effort was made to improve the insulation by screwing additional infill pieces of fibreboard to the coreboard. The results are shown in Fig. 17. The extra fibreboard only increased the sound insulation slightly, because virtually no mass was added and the coreboard was already well damped by the Rockwool. The increase in sound insulation was insufficient to warrant the additional difficulty of fitting the fibreboard. For 145 mm depth of Rockwool in the absorbent leaf, the installation of 50 mm thickness of Rockwool in the cavity of the unabsorbent leaf increased the overall sound insulation; fitting additional plasterboard to the unabsorbent leaf increased the sound insulation further.

As a general rule, the sound insulations of the unperforated partitions were higher than those of the perforated partitions from 100 Hz to 500 Hz; otherwise, the sound insulations were comparable.

Fig. 18 shows predictions of the sound insulations of double leaf partitions having a 37.5% perforated front, the remainder being unperforated (except for the double Camden, which was



(R_w values are shown in brackets)

Fig. 18 - Predictions for double leaf partitions with 37.5% perforated and 625.5% unperforated steel fronts.

unperforated). The absorbent partitions generally perform better than the metal-framed double Camden between 160 Hz and 800 Hz and worse than the metal-framed double Camden above 1 kHz (this shortfall above 1 kHz is not important). For the partition with 75 mm thickness of Rockwool (Fig. 18(b)), the sound insulations at 100 Hz and 125 Hz are probably inadequate. This partition is also undesirable because it is quite heavy, expensive and a disproportionate amount of the sound insulation is provided by the unabsorbent leaf. This might result in difficulties when windows or doors are fitted, and the sound insulation of a triple leaf absorbent partition using this construction would probably be significantly less than that of a triple leaf metal-framed Camden.

Apart from a shortfall at 125 Hz, the sound insulation performance of the partition with 145 mm

thickness of Rockwool (Fig. 18(c)) is generally comparable with that of the metal-framed double Camden. This absorbent partition is probably the best compromise on weight, thickness, cost, sound insulation and absorption. It should have a similar fire rating for spread through the partition as a double Camden, because both partitions contain the same quantity of plasterboard/coreboard. However, the overall fire integrity of this absorbent partition will be lower than that of the double Camden, as discussed later. The installation of Rockwool in the cavity of the unabsorbent leaf increased the sound insulation between 200 Hz and 800 Hz. The fitting of additional plasterboard to the unabsorbent leaf increased the sound insulation further between 80 Hz and 400 Hz.

5. DISCUSSION

For the purposes of this discussion, it is assumed that single and double leaf partitions would be acoustically treated on one side of the partition only and that triple leaf partitions would be treated in both outer leaves. Single leaf absorbent partitions would contain 70 mm thickness of Rockwool with Redland CS70/R studs. A single layer of fibreboard and two layers of plasterboard would be fitted to one side of the studs, with either perforated or unperforated steel facings on the other side. Double and triple leaf partitions would use 146 mm depth of Rockwool in the absorbent leaves.

Table 1 shows the thicknesses of partitions with built-in absorption compared with those of conventional metal-framed Camdens fitted with modular acoustic treatment (the depth of the acoustic treatment *is* included.

Table 1: The thicknesses of partitions with built-in acoustic treatment compared with those of metal-framed partitions fitted with modular acoustic treatment.

Thickness (mm)	Built-in absorption	Using conventional acoustic treatment
Single leaf partition	108	336
Double leaf partition	303	513
Triple leaf partition	506	906

Consider a typical studio, with a floor size of 3 m by 4 m, having an associated sound control room with a floor size of 4 m by 5 m. The total available floor area, for both of the rooms and the partitions, is constant. The partitions are of double leaf construction, apart from the partition separating the two rooms (length 4 m), which is of triple leaf construction. The approximate savings in the available floor areas, resulting from the use of the partitions with built-in acoustic treatment, are:

Sound control room	19%
Studio	24%

In fact, practical savings in floor area would be lower than indicated by these figures. With existing modular acoustic treatment, the studio walls are often not completely treated, so cupboards and bays can be built into the gaps between the acoustic treatment. For partitions with built-in acoustic treatment, such facilities would have to be free-standing in the room. Nevertheless, the potential savings in floor area by using partitions with built-in acoustic treatment are considerable.

In a room, the relative positioning of the wideband and low frequency absorbent sections will be important. The low frequency absorbent sections are very reflective at higher frequencies and should not be placed at the listener's ear height. Otherwise flutter echoes or early reflections might occur. The low frequency absorbent sections could be placed behind the loudspeakers and behind bays of equipment. The wideband and low frequency absorbent sections ought to be well interspersed to give adequate diffusion of the sound field. However, when particularly high levels of sound insulation are required between two rooms, relatively small areas of the wideband absorbent partitioning should be used on the partition between them.

The partitions as tested would probably have inadequate fire resistances. This is because the exposed steel sheet contributes to the strength of the partition and the sheet would lose its strength and buckle in the event of a fire.

One possible way of improving the fire resistance would be to cover the face of the partitions with a fire resistant material. If suitable fire resistant porous absorbers such as Sound Attenuators DS90 panels were secured over the faces of all of the partitions, then the fire resistance would improve. The sound insulation would also improve. The absorption at higher frequencies would increase but probably the low frequency absorption would be relatively unaffected. A disadvantage of installing DS90 panels is that the overall thickness of the partition would increase.

Alternatively, the faces of the partitions could be pre-painted with an intumescent paint. For example, Quelfire manufacture a paint called Steelcote which is designed to protect structural steelwork for

up to two hours. It swells up to 50 times its original thickness to form an insulating char when the temperature reaches 200 °C. In painting the perforated steel sheets, care would have to be taken to ensure that the holes did not become blocked. For aesthetic reasons, it may be considered necessary to cover the partitions with a proprietary stretch fabric system.

The optimum way of overcoming the fire resistance and other potential structural difficulties would be to brace the Shaftwall leaves internally at the junction between the CHS102/W and CS70/R studs. The studs could be braced with an additional layer of perforated steel. This would probably have virtually no detrimental effect on the absorption or the sound insulation of the partition. Alternatively, the junction between the studs could be braced with Redland WFC95/W fixing channel. Sufficient bracing would be required to make the outer perforated/ unperforated steel sheet structurally unnecessary. The centre bracing would be protected from fire by the covering of Rockwool in the leaf of the partition. However, the effects of buckling of the outer layer of steel sheet will have to be considered.

6. CONCLUSIONS

Approximate savings in studio floor area of up to 25% can be obtained by using the partitions with built-in absorption described in this Report, rather than conventional Camdens fitted with modular acoustic treatment. The new partitions weigh slightly less than conventional metal-framed partitions with modular acoustic treatment fitted. Labour and materials costs for construction of the partitions with built-in acoustic treatment are also probably slightly lower than for conventional metal-framed Camden systems.

The primary source of absorption was RW2 grade Rockwool completely filling the cavities of the absorbent metal-framed partitions. The absorbent leaves were faced with 0.7 mm thick perforated and unperforated steel sheet, the relative proportions of each facing determining the overall sound insulation and absorption.

Building absorption into these metal-framed partitions resulted in an overall insulation shortfall of approximately 1 dB, which should be acceptable in most cases. There are no specific sound insulation weaknesses.

The two most significant factors that determine the absorption of these partitions are the type of facing and the thickness of the Rockwool (and hence also the overall thickness of the absorbent leaves). The partitions absorb at low frequencies when the facing is unperforated, and at mid and high frequencies when the facing is perforated. Ideally, the absorbent leaves should contain 150 mm depth of Rockwool, although 70 mm may be adequate for single leaf partitions where the percentage of studio wall area made from single leaf partitions is relatively small.

With 150 mm depth of Rockwool, a typical overall absorption coefficient curve is reasonably flat from 50 Hz to 10 kHz. A field trial would be necessary to determine how the effective absorption inside a complete studio differed from the measured ISO-Standard absorption coefficient. In certain critical studio areas, some fine tuning of the absorption in the room might prove to be necessary. Additional modular absorbers could be secured above an acoustically transparent suspended ceiling.

The fire integrity of these partitions needs to be considered further. For example; the faces of the partitions could be covered with a layer which is both fire retardant and acoustically absorbent; the fronts of the partitions could be painted with a suitable intumescent paint; additional bracing could be secured at the centre of the Shaftwall leaves to make the outer steel face of the leaf structurally unimportant. The latter solution would also overcome any difficulties with the structural loadbearing properties of the partitions.

7. RECOMMENDATIONS

Before the partitions with built-in acoustic treatment can be recommended as alternatives to the conventional Camden, the structural loadbearing capabilities and fire integrities of these partitions must be investigated further by specialists. It may be necessary to provide additional bracing between the different studs in the Shaftwall leaves to make the outer steel sheets structurally unimportant.

8. REFERENCES

1. PLUMB, G.D., 1991. The airborne sound insulations of timber-framed partitions. BBC Research Department Report No. BBC RD 1991/9.

2. PLUMB, G.D., 1991. The airborne sound insulations of metal-framed partitions. BBC Research Department Report No. BBC RD 1991/10.

3. PLUMB, G.D., 1993. Metal-framed partitions with reduced thickness: Part 1 — Narrower studs and cavities. BBC Research Department Report No. BBC RD 1993/5.

4. PLUMB, G.D., 1992. A modular wideband sound absorber. BBC Research Department Report No. BBC RD 1992/11.

5. Redland Drywall Manual 1990. CDT Printers Ltd. November 1989.